

Space Weather Technical Forecast

Issued on Friday 3 January 2025 at 13:29 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: M-class flares likely, with a slight chance of X-class flares. Chance G1 Minor Storms on Day 2 (04 Jan).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: High, with an X1.2 flare observed from AR3947 at 03/1139 UTC.

There are fifteen sunspot regions on the Earth-facing disc. AR3947, in the far northeast, responsible for the recent X-class flare, underwent growth in its leading and trailing regions. AR3939, in the southwest, responsible for an M1.1 flare at 02/1740 UTC, exhibited decay in its trailing spots. AR3944 and AR3945, both moderately sized regions, in south-centre and southeast disc respectively underwent slight decay and simplification in their magnetic configurations. AR3949 was attributed to a small, bipolar region in the southwest disc. A number of other small regions emerged on the facing-disc.

No Earth directed CMEs have been observed in the last 24 hours.

Solar Wind / Geomagnetic Activity: Solar winds, as observed by ACE at L1, showed ongoing but waning CME influence. Wind speeds have shown a generally steady decline from 530km/s to 410km/s in the period. Density was predominantly at average to below average levels, but with a generally above average period (peaking 27ppcc) between 03/0230-0500 UTC. Interplanetary Magnetic Field, Bt, has been largely moderate, but has been fluctuating around the strong (15nT) threshold since 03/0410 UTC. The north-south component, Bz, was initially weakly to moderately negative, before becoming persistently weak to moderately positive from around 02/1720 UTC. The Phi angle was variable, becoming predominantly positive (away from the Sun) around 02/1730 UTC.

Geomagnetic activity was initially Active, between 02/1200-1800 UTC, but has since been at Quiet to Unsettled levels.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) at GOES18 remained background levels. High energy electron flux (greater than 2MeV) at GOES16 was at background to moderate levels with the associated 24 hr fluence well below Active. The 03/0000 UTC fluence observation was 4.78e6 integrated pfu.

Four-Day Space Weather Forecast Summary

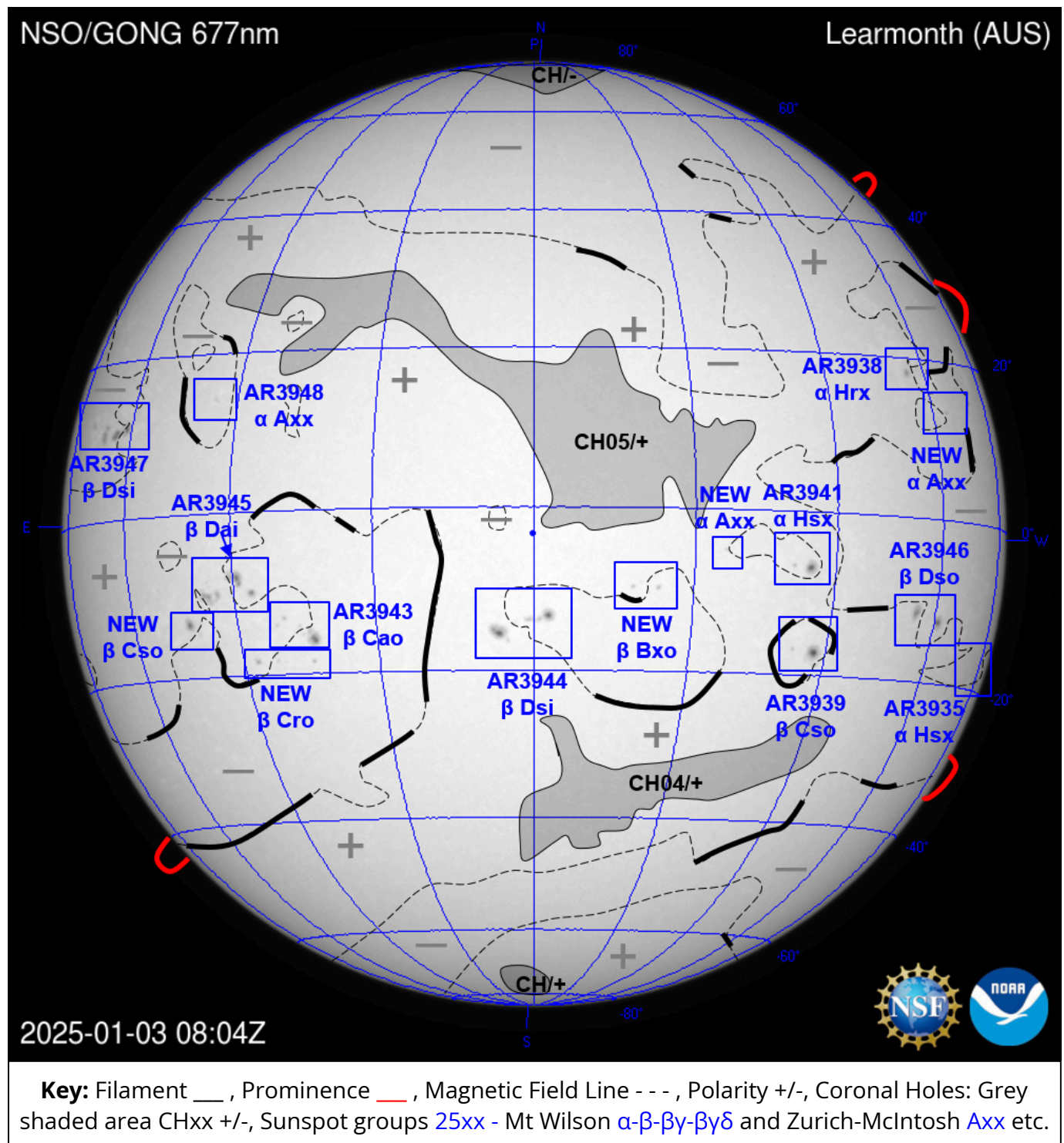
Solar Activity: Moderate to High, with isolated M-class flares considered likely and a slight chance of further isolated X-flares.

Solar Wind / Geomagnetic Activity: There is one potential Earth directed CME, which is expected to pass near Earth early on Day 2 (04 Jan), but with low confidence. Solar winds are currently slightly elevated and continuing to ease following the influence of the two CME arrivals on 31 Dec and 01 Jan. A large coronal hole is expected to bring elevated, perhaps strong solar wind speeds (at peak) between Days 2-4 (04-06 Dec).

Geomagnetic activity is expected to be Quiet to Unsettled initially, with a chance of isolated Active intervals on Day 1 (03 Dec). Between Day 2 and Day 3 (04 and 05 Jan) activity is expected to increase to Unsettled to Active levels, due to CME and/or coronal hole enhancements. There is a high chance of peak G1/Minor Storm conditions and slight chance of G2/Moderate Storm levels occurring. Activity is forecast to subside to Quiet to Unsettled levels on Day 4 (06 Jan).

Energetic Particles / Solar Radiation: GOES18 high energy proton flux is likely to continue at background levels, but with a slight chance of exceeding the S1/Minor Storm threshold. GOES16 high energy electron flux may increase briefly after recent CME activity, before any further solar wind enhancement from Day 2 and 3 (04 and 05 Jan) suppresses this again. The associated fluence is expected to remain below the Active threshold throughout.

Figure 1: MOSWOC Solar Synoptic Map valid 03/0800 UTC.



Geomagnetic Storms

There is one potential Earth directed CME, from a weak filament eruption early on 01 Jan from the vicinity of AR3939. This is expected to pass close to Earth early on Day 2 (04 Jan), perhaps missing ahead of Earth's orbit, but with only glancing effects anticipated if it does arrive.

Solar winds are currently slightly elevated from the aftermath of the multiple CME arrivals between 31 Dec and 01 Jan. This enhancement is expected to continue to decline through Day 1 (03 Jan). There are two notable coronal holes on the Earth-facing disc, CH04+ in the south, and CH05+ in the north. The most likely of these to have an influence on Earth is CH05+, as CH04+ is likely too far south. CH05+ is a persistent feature, and on its previous rotation was smaller and further east. It reached solar wind speeds of around 500-550km/s, reaching Active geomagnetic intervals on the equivalent of Day 3 (05 Jan). Given the current location and the potential for the feature to be stronger than the last rotation (perhaps to around 600km/s), the anticipated connection to the high speed stream from CH05+ may arrive slightly earlier than the last rotation. Therefore there is a chance of the onset of the enhancement during the second half of Day 2 (04 Jan). This is broadly supported in MOSWOC Enlil output.

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Geomagnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	5	40	20	5
Strong	G3	No	1	5	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R _☉ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
01/0740	Partial	Filament	SW	560	04/0100 UTC	Low confidence in any arrival as expected to be a glancing impact at best.

Radio Blackouts - X-Ray Flares

Solar activity has increased to High levels with an X1.2 flare observed at 03/1139 UTC from AR3947.

There are fifteen sunspot regions on the Earth-facing disc. While Ex-AR3936 has rotated over the western limb, it still poses a slight flare risk for the next 6-12 hours or so. Despite the large number of spots on the facing-disc, many are small and magnetically simple. Of the more notable regions, AR3947 in the far northeast, recently responsible for the X1.2 flare, contains a number of moderately sized spots of mixed polarity. Given its currently location on the disc and ongoing degraded coronagraph imagery, it may harbour greater magnetic complexity than indicated. AR3944 in the south-centre disc continues to extend longitudinally, with a more 'open' appearance between its mature lead and trailer spots. AR3945, located in the southeast evolves slowly, as a moderately sized region with limited flaring.

GOES16 SUVI 171 imagery indicates notable magnetic looping at the southeast limb and there is recent evidence of a sunspot rotating into view in magnetogram imagery. This is supported by recent far-sided helio-seismic data.

Overall, activity is forecast to be Moderate to High, with isolated M-class flares considered likely and a slight chance of further isolated X-flares.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	60	60	60	60
Very Active	R3-R5 (X Class)	Yes	10	10	10	10

Solar Radiation Storms (High Energy Protons)

High energy proton flux as observed by GOES-18 is at background levels. Despite the large number of sunspots currently on the facing-disc there are only small contributions towards Proton Storm risks in general. There is still a chance of an enhancement in the next few days from Ex-AR3936, which rotated over the western limb on 02 Jan, should any large flares occur from the region. Overall there is a slight chance of exceeding the S1/Minor Storm threshold during the period.

Radiation Storms	Level (cm ⁻² sr ⁻¹ s ⁻¹)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	10	10	10	10
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = cm ⁻² sr ⁻¹ s ⁻¹)						

High Energy Electrons ($\geq 2\text{MeV}$)

High energy electron flux observed at GOES16 is currently ranging between normal background to diurnally moderate levels. With the solar wind expected to reduce in speed through Day 1 (03 Jan) the Van Allen belt is expected to expand back towards GEO and as a result the electron flux is likely to rise to moderate, possibly high levels at the diurnal max. On Day 2 (04 Jan) a potential glancing CME arrival and possible connection to a high speed stream from CH05+ is forecast to bring elevated, or perhaps strong solar winds, this is expected to act to suppress the radiation belt away from GEO causing the electron flux to return to background levels. However, once any initial geomagnetic activity eases, the observed flux could rise again on Day 4 (06 Jan), although this is low confidence by this time.

Overall the associated 24-hour fluence is expected to persist below Active levels throughout, despite a rising trend likely in the next couple of days and potentially again on Day 4 (06 Jan). MOSWOC REFM has a reasonable trend until Day 2 (04 Jan) when coronal hole and/or combined CME effects are likely to see a reduction in fluence levels.

GEO Electron Environment	Level ($\text{cm}^{-2}\text{sr}^{-1}\text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2\text{ MeV}$ $\geq 1\times10^8$	No	1	1	1	5
Very Active	$\geq 2\text{ MeV}$ $\geq 1\times10^9$	No	1	1	1	1

Figure 2: Latest MOSWOC REFM output and Recurrence.

